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Geoengineering: A New Arena of International Politics

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Introduction: 'Fixing' the Climate Crisis?

The ever-rising concentration of greenhouse gases (GHGs) in the atmosphere and the seeming reluctance or inability to effectively address drivers of emissions has led some to search for new technological interventions to deal with global warming. Known collectively as 'geoengineering' or 'climate engineering', such methods are usually defined as large-scale intentional inventions in Earth systems for climate purposes (Shepherd 2009). Some are designed to artificially cool the planet by reducing incoming sunlight, for example by injecting sulphur in the lower stratosphere, while others seek to remove greenhouse gases from the atmosphere and store them, either via intervening in ecosystems or directly through human-built machinery. All are interventions conceived to act *after* excess emissions have accumulated into the atmosphere, rather than tools to prevent or adapt to such emissions. As such, optimists see in them a possible escape from the quagmire of global climate politics, even if all are still at the early stages of research and development. Sunlight-reducing

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methods are often considered high-leverage yet low cost and as such, it is argued, could make the problem of cost-sharing in global climate politics less acute. By promising future reduction of atmospheric CO_2, carbon removal techniques have raised the tempting prospect of having (or prolonging) high-carbon economies while handling climate change. Others worry that they amount to merely the latest in a series of technological promises that have failed to materialise but have delayed serious decarbonisation: so-called technologies of prevarication (McLaren and Markusson 2020).

However, while IR analysis has been sparse, the emerging international politics of geoengineering appears to share some of the problems of existing climate politics, while also generating new ones. Not only are there potential unwanted and unknown environmental side effects, some technologies may also generate new international climate dilemmas. Further, experts agree emissions reductions will still be needed even in the most optimistic scenarios and, though some geoengineering may be necessary, it may also risk exacerbating political obstacles to the acceleration of conventional greenhouse gas mitigation. Given this Anthropocene dilemma, we suggest the standard rationalist approach to climate change in International Relations (IR) is not sufficient. Its headline problem of self-interested states negotiating global agreements in the face of collective bargaining dilemmas is only one dimension of how international relations and geoengineering matter to each other.

In this chapter, we introduce geoengineering as a new arena of international politics and explain why hopeful technical explorations of alternative climate strategies have not properly factored in the international. We ask how international politics might affect potential development and deployment of geoengineering techniques, and conversely how their emergence could change the international system itself, introducing new dilemmas and modes of interaction characteristic of the Anthropocene. Throughout the chapter, we will draw on two high-profile areas of geoengineering research, namely stratospheric aerosol injection (SAI) and bioenergy with carbon capture and storage (BECCS) (see Boxes 6.1 and 6.2), to illustrate some of the issues that geoengineering poses for IR, both theoretically and in practice. The chapter proceeds via three sections, addressing three key questions. First, what are geoengineering technologies? Second, why has the international not been factored in properly? Third, how might global climate intervention interact with the international? To conclude, we consider what 'the international' implies for theorising IR in the 'Anthropocene' more widely.

What Are Geoengineering Technologies?

All ideas for geoengineering involve large-scale interventions that intentionally alter the global climate to ameliorate global warming. This definition excludes unintended changes to the global climate as well as local weather modification, for example, cloud seeding. Geoengineering techniques (or ideas about them) are diverse but are often put into two overall categories based on distinct mechanisms. They involve different interactions with society and the international system; the international politics of each are, therefore, dissimilar in important ways.

The first kind is known as carbon dioxide removal (CDR) or negative emissions technologies (NETs). These techniques aim to remove greenhouse gases from the atmosphere and store them safely at a scale that either slows or reverses rising atmospheric concentrations. Some are ecosystem-based and rely on stimulating carbon sinks in ecosystems (e.g. forest enhancement or protecting and extending mangroves) while others rely on extensively manufactured infrastructures to do the heavy lifting (e.g. 'artificial trees' otherwise known as direct air capture (DAC)). One of the most commonly discussed forms of CDR involves combining energy production from crops (bioenergy) with carbon capture and storage (BECCS; see Box 6.1). While carbon capture and storage prototypes exist and bioenergy from crops has a longer, though problematic, pedigree, linking the two in the development of BECCS at a globally consequential scale is untried. Huge uncertainty exists over whether BECCS and, indeed, any combination of negative emissions approaches can be delivered at a scale that would make a meaningful difference to atmospheric concentrations of carbon dioxide (Anderson and Peters 2016).

Despite this, negative emissions have already gained wide prominence in climate policy and appear in huge quantities in some of the most influential mitigation scenarios. In their report on limiting climate change at 1.5 °C, the Intergovernmental Panel on Climate Change (IPCC) included large-scale BECCS deployment in three out of four high-level pathways (IPCC 2018, 14). Many states and large corporations have also set 'net zero' greenhouse gas targets which imply some or all of their emissions would be in effect sucked back out of the air; major fossil fuel companies and airlines have also announced their intention to use NETs to achieve these targets (ICRLP 2020). While some measure of NETs may now be unavoidable if safer levels of atmospheric CO_2 are to be achieved, this has raised concerns that NETs may prove counterproductive by causing *mitigation deterrence*: when the prospect of being able to remove GHGs in the future changes incentives and planning scenarios, potentially delays or prevents near-term emissions cuts.

Box 6.1 Bioenergy with Carbon Capture and Storage

BECCS is currently the main CDR technology currently included in IPCC's 1.5 °C scenarios (IPCC 2018, 14), largely as an artefact of the way the underlying models have been developed and operated (Mander et al. 2017, 6038). Despite it, therefore, being a central plank in current plans to deal with climate change, it remains a speculative technology at scale. BECCS involves energy production from plant biomass while capturing some of the carbon dioxide emitted during combustion and then storing it indefinitely (geological reservoirs are the most typical proposed locations). However, to deliver global impacts, a massive expansion of plantation crops or forests would be necessary—one to two times the area of India according to some estimates (Smith et al. 2016, 46), if BECCS were to do all of the work asked of CDR in climate model projections of the future. This scale of land use would impact the land available for food production, and BECCS would be subject to resource constraints, including soil nutrients and water use (Smith et al. 2016). Social implications of large-scale land use change are also unavoidable. Experiences with related technologies such as forest carbon sequestration and biofuel production indicate that adverse social effects, such as land grabbing and population displacement, are likely absent concerted political intervention (Buck 2016, 164).

Proposals for *solar radiation management* (SRM) would attempt to cool the planet directly by reflecting more incoming solar radiation. The most prominent proposal involves injecting an aerosol (e.g. sulphur) into the lower stratosphere to increase the reflectivity of the Earth, producing a cooling effect (see Box 6.2), but there are other ideas such as increasing the albedo (reflective effect) of marine clouds or gene manipulation of crops to make them lighter in colour for the same purpose. The contemporary wave of research into SRM started in 2006 when prominent scientists argued that SRM ought to be explored as a possible 'plan B', in case the 'plan A' of mitigation and adaptation fails (Crutzen 2006; Shepherd 2009). In recent years, increasing concern over climate 'tipping points' (Steffen et al. 2018) have led some scientists and policy advisors to go further, advocating for SRM as a temporary supplement to emissions cuts and CDR (Honegger et al. 2018, 18; MacMartin et al. 2018). The IPCC's next assessment report is also expected to devote considerably more attention to SRM measures (IPCC 2017a, b).

Like all technological innovations, research into geoengineering is structured by ideas about how it will, or should be, bound together with society. In this sense, geoengineering can be understood as *sociotechnical imaginaries*, which connect prospective material technologies with "publicly performed visions of desirable futures" for a society (Jasanoff 2015, 4). The dominant sociotechnical imaginary of geoengineering is characterised by a planetary framing that tends to hide to full implications of *the international*: the

Box 6.2 Stratospheric Aerosol Injection

Stratospheric aerosol injection (SAI) is an experimental solar radiation management (SRM) technology with potential high-leverage global effects. In some scenarios, planes or high-altitude balloons would spray an aerosol into the atmosphere 20 km above sea level, blocking out a small fraction of incoming sunlight and thereby cooling the planet. However, the effects of such interventions are highly uncertain and to some extent unpredictable. Since the effects of SAI cannot be empirically tested except by actual deployment, research has hitherto relied on simulations in Earth System models (Irvine et al. 2016, 828). Modelling studies show significant variation in their results, and there is uncertainty and disagreement over which variables have most significance (McLaren 2018, 211). However, simulations suggest that SAI cannot 'restore' earlier climates or mask the effects of high GHG concentrations perfectly; for instance, SAI would affect temperature and precipitation differently to the effects of a reduction in greenhouse gases. It also appears that SAI deployment would involve trade-offs that could leave some regions 'worse off' than others (Irvine et al. 2016), although this depends on the size of 'regions' and parameters examined. Some studies have suggested that SAI may cause worrying regional disruptions, for example, that the Amazon might experience severe rainfall reduction (Jones et al. 2018). Another concern is that the effects of a sudden disruption of SAI, known as a 'termination shock', would cause unprecedented rapid climate change (McCusker et al. 2014) although some argue that policymakers could easily prevent this (Parker and Irvine 2018).

co-existence of multiple societies (Rosenberg 2016). In what follows, we explore the implications of bringing the international into the understanding of geoengineering. We show how despite being billed as a useful supplement, geoengineering may be politically infeasible and end up complicating climate politics even further.

The Elusive International

Geoengineering has so far been debated, studied and assessed without taking the international dimension fully into account (Corry 2017a). On the one hand, for climate modellers, the world is one interconnected place of physical stocks and flows, and the role of human society is understood as external inputs to this system (chiefly greenhouse gas emissions and modification of carbon sinks) (Demeritt 2001; Taylor 2015, 26–45). On the other hand, the environment in IR is typically not theorised as being part of the international system—at the most, it is seen as an external part of the world in the form of resources to be exploited or something in need of governance (Corry 2017b, 2020).

Most of the climate modelling that simulates the possible risks and benefits of stratospheric aerosol injection, for example, excludes "geopolitical strife over attempts to implement geoengineering" (Kravitz et al. 2014, 6). For analytical reasons, many climate model studies assume a "central planner framing" (e.g. Keith and MacMartin 2015, 201) or a 'global utility function'—both of which leave out the many implications of the world being divided into multiple uneven societies: 'the international' (Rosenberg 2016). Metaphors of SRM also tend to project the idea that a singular global actor would be doing the global cooling (or carbon sequestration), for example, as a medical drug that a doctor could choose to administer. Here, not only is the geoengineer singular, but the Earth is by implication an individual body or 'patient' in need of therapy (see Nerlich and Jaspal 2012). Similarly, one science writer compared SRM with a putative singular actor "reaching for the planetary car keys", relying on the idea of Earth as a car and the geoengineer as the driver (Kintisch 2010, 232).

Yet the delivery of a global-scale SRM intervention in the climate system would necessarily take place within the international system and thus would be marked by the many consequences of a politically fragmented and uneven world of multiple societies. By one account, this is the essence of *the international*: that social life is never singular as long as there is societal multiplicity and that this has far-reaching consequences (Rosenberg 2016). This covers the obvious international diplomacy and institutions or regime-building (Young 1989) around climate change but also the *causes and drivers* of anthropogenic climate change, and even ostensibly 'domestic' factors such as political regimes of technological innovation. All realms of social life, including domestic reactions to climate change, are almost invariably conditioned by, or take into account, the existence of an international world of multiple uneven societies.

Only in limited ways has the international featured in debates about geoengineering. Some modelling studies look into potential regional effects of SRM on climates, but this typically examines only differences in climate outcomes between regions rather than the full range of complications arising from the co-existence of multiple different societies. Societies inevitably have different histories, develop different political and economic systems, harbour different understandings of climate fairness, of themselves and their security, all resulting in different needs from and expectations of climate control (Wiertz 2016) and widely diverging perceived interests and strategies vis-a-vis other societies. The interaction of multiple societies will, therefore, deeply affect any processes related to research, development or governance of geoengineering. For instance, development of a technological capability in one state may prompt or guide similar or different initiatives in others, as seen in other cutting-edge technology spheres such as artificial intelligence (Armstrong et al. 2016).

For its part, 'climate change IR' has been dominated by 'environmental multilateralism': a focus on state negotiations and the international institutional regime around mitigation of greenhouse gas emissions (Corry and Stevenson 2017, 6). The United Nations Framework Convention on Climate Change (UNFCCC) and its annual Conference of Parties (COP) meetings have arguably been the main events through which such IR scholars have digested the intersection of the international and the climate. Such focus on diplomacy, summitry and (failed) agreements assumes that states are the main (though not the sole) actors in global climate politics and that institutions and norms to coordinate action among self-interested actors are the key policy question (Keohane 2005; Young 1989; Keohane and Victor 2011). The sparse IR literature on geoengineering has often taken this overall approach (Horton and Reynolds 2016; Reynolds 2019). Climate conflict (Nordås and Gleditsch 2007; Hsiang and Burke 2014) and wider questions of 'climate security' (though the content of this varies, see McDonald 2013) have also attracted attention, emphasising the anarchic backdrop to climate politics or its tendency to be drawn into security politics. Finally, another smaller, but growing, cluster of research focuses on the role of political economy, the international system and nonhuman nature (Malm and Hornborg 2014; Moore 2015; Newell and Lane 2017), emphasising historical materialist themes in social, technological and ecological interactions (Corry 2020).

Geoengineering and the International

This section considers geoengineering first as a challenge of *environmental multilateralism*, then in terms of *climate anarchy* and finally through the lens of *materialist international* approaches.

Rationalist approaches to geoengineering place decisive emphasis on costs and benefits to rational actors and the possible *multilateral* responses to a basic collective action dilemma where free-riding is the main challenge. SRM has drawn most of the attention of IR scholars interested in geoengineering because the basic incentive structure is considered different compared to CDR and emissions cuts: For Barrett, "Because [solar geoengineering] consists of a single project, it can be undertaken unilaterally or minilaterally. Because of its low cost, the incentives for it to be tried are very strong" (2008, 50). Due to their high-leverage and global impacts, solar methods are thought to "pose grave and novel challenges to governance" (Parson 2017, 2). A typical research question concerning 'governing' stratospheric aerosol injection is, therefore, "what international capacity and authority would be needed to make informed, prudent, legitimate decisions regarding proposed large-scale interventions, whether for research or operational deployment?" (Parson 2017, 3).

While different national laws exist regulating environmental interventions, there is currently no specific formal international mechanism with the explicit purpose of regulating SRM. Existing frameworks designed for other purposes provide only a patchy regime. The UNFCCC's focus on greenhouse gas concentrations means that SRM methods, such as stratospheric aerosol injection, mainly fall outside its remit. The Environmental Modification treaty, ENMOD, prohibits hostile use of environmental modification, but this would not cover SRM for peaceful purposes, and not all states have signed up to the treaty. Interventions that might affect ozone could fall under the Montreal Protocol while sulphur interventions could be covered by agreements designed to curb acid rain. Similarly, the London Protocol on Dumping of Waste at Sea provides some constraints for interventions such as ocean iron fertilisation that involve releasing matter into the ocean. The Convention on Biological Diversity (CBD) is perhaps the most directly relevant treaty for SRM, since it is probable that large-scale SRM would affect biodiversity in some way. The CBD Conference of Parties is also the only major international legal forum to have issued statements on SRM, most recently in 2016. These non-binding statements have expressed precaution, calling for more research on potential biodiversity impacts and urging states not to deploy geoengineering (both NETs and SRM) in absence of thorough risk assessments (Reynolds 2018). Notably, however, the US is not a party to the CBD.

Thus, certain aspects of SRM might be covered by existing international agreements, but the absence of substantial and explicit provisions mean that it is highly uncertain how the current international legal framework would respond to SRM deployment, whether uni- or multilateral. This has led many scholars and policymakers to argue that new governing mechanisms are needed, including in a landmark Royal Society report (Shepherd 2009, ix) which did, however, give the go-ahead for accelerated research and development. Scenarios for how a multilateral regime might emerge in the context of differing interests tend to rely on rationalist assumptions to construct scenarios where cooperation develops under conditions of anarchy (e.g. Guzman 2008). Some suggest a small group may start up a 'mini-lateral' set of rules that other states would then be incentivised to join in order to exert influence over the emerging regime (Lloyd and Oppenheimer 2014). Others use formal game theory and estimates of stratospheric aerosol injection's potential regional impacts to explore potential coalitions in favour of it (Ricke et al. 2013). However, international agreements on much less controversial environmental questions have proven extremely difficult to achieve and sustain, and early indications from UN negotiations on geoengineering governance do not look promising (see Box 6.3).

For others, a multilateral governance imaginary is too optimistic and overlooks the basic *anarchic* dynamics of the international. As the COVID-19 pandemic broke out, the world had huge incentives to cooperate, since no country would be safe without all being safe, and coordination of production of vital equipment could have optimised global supply and distribution. Yet the US suspended its funding of the only existing multilateral health institution, the World Health Organization (WHO), and competition in procurement of personal protective equipment was rife. Realist IR has traditionally explained such outcomes as a result of the anarchic structure of the international, whereas constructivists consider such outcomes contingent on certain forms of interaction and identity-formation producing particular 'logics of anarchy' (Wendt 1999). Both, however, would argue that the institutionalist approach mistakenly treats the international climate problem as one of coordination or cooperation on the basis of common interests and outlooks. It cannot be assumed that states would use high-leverage geoengineering capabilities to some universal aim of global betterment, nor their rational self-interest in projected temperature or precipitation outcomes. Conceivably, "rather than under-provision, the main threats [of SAI] are of competitive, predatory, parochial, and other unethical forms of provision" (Gardiner 2013, 524), as states seek to further their own competitive interests. Developing the ability to intentionally alter the global climatic system would, even if pursued for reasons related to a 'common good', amount to a strategic power resource, potentially affecting other states' material interests and perceptions. As Chalecki and Ferrari note "(a)ny geoengineering technology on a scale large enough to shift the global climate has the potential to inflict damage of the same magnitude" (2018, 86).

Partly, such questions of conflict versus cooperation depend on the prevailing 'mood music' of the international system, that is, whether tensions are high in a culture of anarchy dominated by enmity or one characterised by friendliness and cooperation. If climate problems are increasingly seen through a lens of 'security' and 'climate emergency', the potential rises for climate technologies to become seen as part of anarchic security dilemmas. But technical features of geoengineering technologies may also play a role. Stratospheric aerosol injection could become a *facilitating condition* for the *securitisation* of climate change (Wæver 2000, 253) and make it easier to turn climate change into a 'security' issue: one in which extraordinary measures are justified by reference to an existential threat. This could be by reference to extreme weather, migrants (weaponised politically as a threat) or via food insecurity. By introducing the possibility of *intentional* climate change, a geoengineered climate becomes more identifiable as a threat, since it could be plausibly attributed to a particular actor (Corry 2017a). The hope that SRM would 'buy time' to let states agree on climate mitigation (e.g. Whaley and Leinen 2018) would then be sabotaged by such securitisation undermining the multilateral climate regime. Added to this, military actors are likely to be involved in deploying or protecting stratospheric aerosol infrastructure linking it closer to national security dynamics (Lockyer and Symons 2019, 487).

In addition, the multilateral and realist accounts may not consider how societies have different "civic epistemologies" (Jasanoff 2010: 239) that structure how scientific evidence interacts with policymaking. This was a major obstacle during the first negotiations over geoengineering governance (see Box 6.3). Such issues make it difficult to agree on how a multilateral institution should govern research and deployment, even before different national interests are considered.

Box 6.3 The UN Environment Assembly, Nairobi, 2019: The First International Negotiations over Geoengineering

The 2019 UN Environment Assembly (UNEA), held in Nairobi, Kenya, saw state representatives coming together to discuss a UN resolution on geoengineering for the first time. Switzerland presented what many considered to be a modest initiative, proposing an expert study of risks and benefits, including ways of adequately governing each technology. However, the negotiations almost immediately ran into trouble. On the surface, the main disagreements were whether SRM and CDR should be included under a single study; whether it was too early to commission a study; and whether UNEA or the IPCC was the appropriate venue for assessment. The US and Saudi Arabia wanted SRM and CDR clearly distinguished, claimed a UNEA-based study would 'distract' the IPCC and, in the end, argued it was simply 'too early' for a study. Others agreed to distinguish the two approaches but resisted a watered-down text that omitted references to existing global governance. The EU and Bolivia insisted on a reference to the Precautionary Principle. In the end, the Swiss delegation withdrew the resolution.

The outcome was subject to different interpretations. Some found it hard to believe the sincerity of the US and Saudi's worries for the IPCC. They pointed to the long track record of climate obstruction and the vested interests of the world's biggest oil producers in leaving particularly CDR ungoverned. Deeper knowledge-issues also surfaced: some states thought of climate as a technical problem. Their main question for geoengineering was 'will it work?' and scientific climate models were assumed to be the best knowledge base for decision-making. By contrast, others used North-South inequalities and the concept of climate justice as their frame of reference, attributing geoengineering with a problematic potential to perpetuate unequal power relations. Still others, guided by the precautionary principle, were mainly concerned about what was *not* known about geoengineering, considering further investigation of uncertainties and side effects, technical as well as political, the most important matter. Regardless, the Nairobi negotiations were a warning signal that geoengineering is not immune to the international complications so familiar from existing climate politics.

Other approaches such as International Political Economy of the Environment (IPEE), drawing on a *materialist* tradition, argue that two decades of overriding concern with environmental agreements between states have "allowed little room for engagement with, and theorisation of, causation, social relations and the politics and possibilities of transformation" (Newell and Lane 2017, 137). One central figure, David Harvey, laments that the dominant social formation, capital, while at the heart of the cause of environmental destruction, "is able to displace responsibility for environmental problems and circumvent calls for regulation" (quoted in Newell and Lane 2017, 143).

The solution advocated is, therefore, more international analysis of the processes and structures that drive environmental change, including the economic systems and distributions of power underpinning the state system. Jason Moore has characterised the global world system and the Earth system as effectively inseparable: global nature is today permeated by global capitalism which requires continuous and expanding supplies of 'cheap nature' in the form of unpriced or underpaid work, resources, energy or food. Successive waves of exploitation or appropriation of free or cheap ecosystem services are gradually exhausted or monetised (gain a price tag, e.g. carbon pricing), causing economic crisis. This triggers attempts to secure new sources of cheap nature, for example, via colonisation or exploration in new pristine habitats, to stave off system crisis yet again (Moore 2015).

In this framework, geoengineering of both types can be seen in relation not just to multilateral institutions or in terms of a security dilemma between states. The techniques must also be recognised as part-and-parcel of patterns of uneven international appropriation and exchange of resources, power and risks. Geoengineering makes for new forms of international interaction, playing into existing power differentials and sustaining or disrupting patterns in the 'metabolism' between human societies and nonhuman nature. For example, large-scale deployment of BECCS envisaged in some IPCC scenarios (IPCC 2018, 14–17) could cause immense pressure on land, water and other resources (Smith et al. 2016). Such pressures would interact with international political economy; for example, afforestation or biofuel production in the Global South may allow the Global North's fossil fuel-based societal model to be extended, reducing the pressure to decarbonise.

This may alter international flows and patterns of development as well as strategic calculations in relation to resource-rich countries. Special interests in those countries may push for CDR policies in the Global North. Brazil has lobbied the European Union to increase biofuel requirements in its Renewable Energy Directive in order to make income from exports, despite serious domestic detrimental consequences for biodiversity, human rights and rural livelihoods (Franco et al. 2010, 680–683). The demand for CDR is also driven by multinational corporations like Microsoft and oil companies, buying CDR and carbon sinks in order to claim carbon neutrality, for example, by planting trees in the cheapest spots (McLaren and Burns forthcoming). The next generation may be left a 'carbon debt' and to pay for emissions cuts and expensive CDR that were both deferred to the future (McLaren et al. 2019). Moreover, future negative emissions could fail to materialise, and if they do materialise, for example, via BECCS, recaptured and stored carbon may be at higher risk than unburnt fossil fuels (e.g. forest fires may re-release carbon sequestered through afforestation). Methods like stratospheric aerosols also entail novel risks, for example, to precipitation patterns that may be unequally distributed across regions.

Conclusion: Geoengineering and IR in the Anthropocene

Geoengineering may be considered the quintessentially 'Anthropocene' approach, designed as it is to intentionally manipulate the Earth system. What general lessons can we learn from it about international relations in the Anthropocene? Unfortunately, the current field of IR has mostly not conceived of the natural world as integral to international politics; 'nature' has been placed firmly on the outside, as something to be governed or perhaps exploited as a power resource (Corry 2017b). For neorealists and institutionalists especially, the physical environment is absent or taken for granted as a factor external to international politics. To remedy this, some IR scholars inspired by posthumanism and new materialism (see Chaps. 2 and 13) have proposed a new way to break with the nature/society distinction entirely. They aim to replace conventional notions of IR as anarchic politics between states with a focus on "the collective human interaction with the biosphere" (Burke et al. 2016, 501). This refocuses IR away from only states and human societies to all human and nonhuman life and their intermingling.

However, collapsing the analytical boundary between nature and society does not necessarily aid analysis of the *interaction* between the two (Malm 2018). And while invoking the planet as a whole fits well with Anthropocene discourse, it also constructs a singular 'humanity' which tends to hide the role of the international, including those inequalities between groups or societies that were key drivers of climate change in the first place (Corry 2020, 423–4). Another solution favoured by historical materialists is, therefore, to focus on the 'social metabolism' between nature and societies: since humans are part of nature and derive their means of sustenance and security from it, the organisation of human activity affects the physical environment, *and* vice versa (Foster 2000). For IR, recognising that societies are both connected and separated through this *metabolism* provides an important tool to understand the international in 'Anthropocene' conditions (Corry 2020).

This implies that climate change and geoengineering, through their effects on the social metabolism of societies, also change the workings of the international system by altering the ways in which societies are separated from and connected to each other. Conversely, international dynamics are extremely important for the feasibility of particular planetary technologies and how these ultimately end up intervening in the climate problem. In the Anthropocene, in particular, the international cannot be thought of as separate from the natural world, just as nature itself is deeply and constantly transformed by the co-existence of multiple societies.

Key Points

1. Geoengineering is different from unintended or local weather modification in its intentionality and as a response to global warming. Methods are traditionally divided into carbon dioxide removal (CDR) or solar radiation management (SRM).
2. All the key technologies are currently uncertain and would involve different risks, but none would be effective replacements for continued or accelerated reductions in greenhouse gas emissions.
3. Most studies of geoengineering technologies and metaphors used to communicate them ignore or downplay the potential complications arising from the international.
4. Environmental multilateralism focuses on formal agreements and cooperation between states. A limited number of existing regimes apply to geoengineering. Rationalist assumptions about state action and incentives have a patchy record.
5. Climate anarchy approaches emphasise the links between climate and conflict, and geoengineering could interact with some of those connections including through dual use of technology, the *securitisation* of geoengineering and the risk that intentional manipulation of the climate could lead to new tensions.
6. Materialist approaches to the international emphasise that geoengineering would affect the underlying political economy of world politics, which could affect global power politics and lead to a transfer of risks between North and South. This puts a wider notion of climate justice than just 'who pays' at the centre of international geoengineering politics.

Key Questions

1. How do carbon dioxide reduction technologies and solar radiation management techniques differ in (a) technical terms, (b) in terms of international challenges?
2. Why are mainstream IR approaches badly attuned to the role of nonhuman nature in world politics?
3. How do 'globalist' assumptions in climate change research and environmentalist ideas obscure the significance of the international for assessing the feasibility and desirability of geoengineering?
4. Why might 'environmental multilateralists' be more optimistic about the possibility of governing geoengineering technologies than analysis from 'climate anarchy' or the 'materialist international' camps?
5. To what extent does whether we will ultimately have a 'good Anthropocene' or a 'bad Anthropocene' depend on the future of the international order?

Further Reading

Baskin, J. 2019. *Geoengineering, the Anthropocene and the End of Nature*. London: Palgrave Macmillan.

Buck, H. J. 2019. *After Geoengineering: Climate Tragedy, Repair, and Restoration*. London: Verso.

Corry, O. 2017. The international politics of geoengineering: The feasibility of Plan B for tackling climate change. *Security Dialogue* 48(4): 297–315.

Hulme, M. 2014. *Can Science Fix Climate Change? A Case Against Climate Engineering*. John Wiley & Sons.

Keith, D. 2013. *A Case for Climate Engineering*. Cambridge: MIT Press.

Lockyer, A. and Symons, J. 2019. The national security implications of solar geoengineering: an Australian perspective. *Australian Journal of International Affairs* 73(5): 485–503.

McLaren, D. and Markusson, N. 2020. The co-evolution of technological promises, modelling, policies and climate change targets. *Nature Climate Change* 10: 392–397.

Morton, O. 2015. *The planet remade: How geoengineering could change the world*. Princeton: Princeton University Press.

References

Anderson, K. and Peters, G. 2016. The trouble with negative emissions. *Science* 354(6309): 182–183.

Armstrong, S., Bostrom, N. and Shulman, C. 2016. Racing to the precipice: a model of artificial intelligence development. *AI & Society* 31(2): 201–206.

Barrett, S. 2008. The Incredible Economics of Geoengineering. *Environmental Resource Economics* 39: 45–54.

Buck, H. J. 2016. Rapid scale-up of negative emissions technologies: social barriers and social implications. *Climatic Change* 139(2): 155–167.

Burke, A., Fishel, S., Mitchell, A., Dalby, S. and Levine, D. J. 2016. Planet Politics: A Manifesto from the End of IR. *Millennium* 44(3): 499–523.

Chalecki, E. L., Ferrari, L. L. 2018. A New Security Framework for Geoengineering. *Strategic Studies Quarterly* 12(2): 82-106.

Corry, O. 2017a. The international politics of geoengineering: The feasibility of Plan B for tackling climate change. *Security Dialogue* 48(4): 297–315.

Corry, O. 2017b. The 'Nature' of International Relations: From Geopolitics to the Anthropocene. In Eroukhmanoff, C. and Harker, M. (eds) *Reflections on the Posthuman in International Relations: The Anthropocene, Security and Ecology*. Bristol: E-International Relations Publishing.

Corry, O. 2020. Nature and the international: towards a materialist understanding of societal multiplicity. *Globalizations* 17(3): 419–435.

Corry, O. and Stevenson H. 2017. IR and the Earth: Societal multiplicity and planetary singularity. In Corry, O. and Stevenson, H. (eds) *Traditions and Trends in Global Environmental Politics*. Abingdon, Oxon and New York: Routledge, 102–118.

Crutzen, P. J. 2006. Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma? *Climatic Change* 77(211): 211–220.

Demeritt, D. 2001. The Construction of Global Warming and the Politics of Science. *Annals of the Association of American Geographers* 91(2): 307–337.

Foster, J. B. 2000. *Marx's Ecology*. New York: New York University Press.

Franco, J., Levidow, L., Fig, D., Goldfarb, L., Hönicke, M. and Luisa Mendonça, M. 2010. Assumptions in the European Union biofuels policy: frictions with experiences in Germany, Brazil and Mozambique. *The Journal of Peasant Studies* 37(4): 661–698.

Gardiner, S. M. 2013. Why geoengineering is not a 'global public good', and why it is ethically misleading to frame it as one. *Climatic Change* 121(3): 513–525.

Guzman, A.T. 2008. *How international law works: a rational choice theory*. Oxford: Oxford University Press.

Honegger, M., Derwent, H., Harrison, N., Michaelowa, A. and Schäfer, S. 2018. *Carbon Removal and Solar Geoengineering: Potential implications for delivery of the Sustainable Development Goals*. New York: Carnegie Climate Geoengineering Governance Initiative.

Horton, J. B. and Reynolds, J. L. 2016. The international politics of climate engineering: A review and prospectus for international relations. *International Studies Review* 18(3): 438–461.
Hsiang, S. M. and Burke, M. 2014. Climate, conflict, and social stability: what does the evidence say?. *Climatic Change* 123(1): 39–55.
ICRLP. 2020. *Carbon Removal Corporate Action Tracker*. Institute for Carbon Removal Law and Policy, American University. https://research.american.edu/carbonremoval/2020/05/07/carbon-removal-corporate-action-tracker/ [Accessed 23 May 2020].
IPCC 2017a. *Decision: Chapter Outline of The Working Group I Contribution to the IPCC Sixth Assessment Report (AR6)*.
IPCC 2017b. *Decision: Chapter Outline of The Working Group III Contribution to the IPCC Sixth Assessment Report (AR6)*.
IPCC. 2018. Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. Geneva: World Meteorological Organisation.
Irvine, P. J., Kravitz, B., Lawrence, M. G. and Muri, H. 2016. An overview of the Earth system science of solar geoengineering. *WIREs Climate Change* 7(6): 815–833.
Jasanoff, S. 2010. A New Climate for Society. *Theory, Culture & Society* 27(2–3): 233–253.
Jasanoff, S. 2015. Future Imperfect: Science, Technology and the Imaginations of Modernity. In S. Jasanoff and Kim, S.-H. (eds) *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*. Chicago: University of Chicago Press.
Jones, A. C., Hawcroft, M. K., Haywood, J. M., Jones, A., Guo, X. and Moore, J. C. 2018. Regional Climate Impacts of Stabilizing Global Warming at 1.5 K Using Solar Geoengineering. *Earth's Future* 6(2): 230–251.
Keith, D. W. and MacMartin, D. G. 2015. A temporary, moderate and responsive scenario for solar geoengineering. *Nature Climate Change* 5(3): 201–206.
Keohane, R. O. 2005. *After hegemony: Cooperation and discord in the world political economy*. Princeton: Princeton University Press.
Keohane, R. O. and Victor, D. G. 2011. The regime complex for climate change. *Perspectives on Politics* 9(1): 7–23.
Kintisch, E. 2010. *Hack the planet: science's best hope-or worst nightmare-for averting climate catastrophe*. John Wiley & Sons.
Kravitz, B., MacMartin, D. G., Robock, A., Rasch, P. J., Ricke, K. L., Cole, J. N. S., Curry, C. L., Irvine, P. J., Ji, D., Keith, D.W., Kristjánsson, J. E., Moore, J. C., Muri, H., Singh, B., Tilmes, S., Watanabe, S., Yang, S., and Yoon, J.-H. 2014. A multi-model assessment of regional climate disparities caused by solar geoengineering. *Environmental Research Letters* 9: 074013.

Lloyd, I. D. and Oppenheimer, M. 2014. On the Design of an International Governance Framework for Geoengineering. *Global Environmental Politics* 14(2): 45–63.

Lockyer, A. and Symons, J. 2019. The national security implications of solar geoengineering: an Australian perspective. *Australian Journal of International Affairs* 73(5): 485-503.

MacMartin, D. G., Ricke, K. L. and Keith, D. W. 2018. Solar geoengineering as part of an overall strategy for meeting the 1.5°C Paris target. *Philosophical Transactions of the Royal Society A* 376(2031): 20160454.

Malm, A. 2018. *The Progress of this Storm: Nature and Society in a Warming World*. London: Verso.

Malm, A. and Hornborg, A. 2014. The geology of mankind? A critique of the Anthropocene narrative. *The Anthropocene Review* 1: 62–69.

Mander, S., Anderson, K., Larkin, A., Gough, C. and Vaughan, N. 2017. The Role of Bio-energy with Carbon Capture and Storage in Meeting the Climate Mitigation Challenge: A Whole System Perspective. *Energy Procedia* 144: 6036-6043.

McCusker, K. E., Armour, K. C., Bitz, C. M. and Battisti, D. S. 2014. Rapid and extensive warming following cessation of solar radiation management. *Environmental Research Letters* 9: 024005.

McDonald, M. 2013. Discourses of climate security. *Political Geography* 33: 42–51.

McLaren, D. and Burns, W. forthcoming. It would be irresponsible, unethical and unlawful to rely on negative emission techniques at large scale instead of mitigation. In Mayer, B. and Zahar, A. (eds) *Debating Climate Law.* Cambridge: Cambridge University Press.

McLaren, D. and Markusson, N. 2020. The co-evolution of technological promises, modelling, policies and climate change targets. *Nature Climate Change* 10: 392–397.

McLaren, D. P. 2018. Whose climate and whose ethics? Conceptions of justice in solar geoengineering modelling. *Energy Research & Social Science* 44: 209–221.

McLaren, D. P., Tyfield, D. P., Willis, R., Szerszynski, B. and Markusson, N. O. 2019. Beyond "Net-Zero": A Case for Separate Targets for Emissions Reduction and Negative Emissions. *Frontiers in Climate* 1: 4.

Moore, J. W. 2015. *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*. London: Verso.

Nerlich, B. and Jaspal, R. 2012. Metaphors We Die By? Geoengineering, Metaphors, and the Argument from Catastrophe. *Metaphor and Symbol* 27(2): 131–147.

Newell, P. and Lane, R. 2017. IPE and the environment in the age of the Anthropocene. In Corry, O. and Stevenson, H. (eds) *Traditions and Trends in Global Environmental Politics*. Abingdon, Oxon and New York: Routledge, 136–153.

Nordås, R. and Gleditsch, N. P. 2007. Climate change and conflict. *Political geography* 26(6): 627–638.

Parker, A., and Irvine, P.J. 2018. The Risk of Termination Shock From Solar Geoengineering. *Earth's Future* 6(3): 456–467.

Parson, E. A., 2017. *Starting the dialogue on climate engineering governance: a world commission*. Retrieved from Policy Brief: Fixing Climate Governance Series Waterloo, ON.

Reynolds, J. L. 2018. The International Legal Framework for Climate Engineering. In Blackstock, J. J. and Law, S. (eds) *Geoengineering Our Climate?: Ethics, Politics and Governance*. London: Routledge, 125–136.

Reynolds, J. L. 2019. *The governance of solar geoengineering: Managing climate change in the Anthropocene*. Cambridge: Cambridge University Press.

Ricke, K. L., Moreno-Cruz, J. B., Caldeira, K. 2013. Strategic incentives for climate geoengineering coalitions to exclude broad participation. *Environmental Research Letters* 8: 014021.

Rosenberg, J. 2016. International Relations in the prison of Political Science. *International Relations* 30(2): 127–153.

Shepherd, J. 2009. *Geoengineering the climate: science, governance and uncertainty*. London: The Royal Society.

Smith, P., Davis, S. J., Creutzig, F., Fuss, S., Minx, J., Gabrielle, B., Kato, E., Jackson, R. B., Cowie, A., Kriegler, E., van Vuuren, D. P., Rogelj, J., Ciais, P., Milne, J., Canadell, J. G., McCollum, D., Peters, G., Andrew, R., Krey, V., Shrestha, G., Friedlingstein, P., Gasser, T., Grübler, A., Heidug, W. K., Jonas, M., Jones, C. D., Kraxner, F., Littleton, E., Lowe, J., Moreira, J. R., Nakicenovic, N., Obersteiner, M., Patwardhan, A., Rogner, M., Rubin, E., Sharifi, A., Torvanger, A., Yamagata, Y., Edmonds, J. and Yongsung, C. 2016. Biophysical and economic limits to negative CO_2 emissions. *Nature Climate Change* 6(1): 42–50.

Steffen, W., Rockström, J., Richardson, K., Lenton, T. M., Folke, C., Liverman, D., Summerhayes, C. P., Barnosky, A. D., Cornell, S. E., Crucifix, M., Donges, J. F., Fetzer, I., Lade, S. J., Scheffer, M., Winkelmann, R. and Schellnhuber, H. J. 2018. Trajectories of the Earth System in the Anthropocene. *Proceedings of the National Academy of Sciences of the United States of America* 115(33): 8252–8259.

Taylor, M. 2015. *The Political Ecology of Climate Change Adaptation: Livelihoods, Agrarian Change and the Conflicts of Development*. Abingdon, Oxon and New York: Routledge.

Wæver, O. 2000. The EU as a security actor: Reflections from a pessimistic constructivist on post-sovereign security orders. In Williams, M.C. and Kelstrup, M. (eds) *International Relations Theory and the Politics of European Integration: Power, Security, and Community*. Abingdon, Oxon and New York: Routledge.

Wendt, A. 1999. *Social Theory of International Politics*. Cambridge: Cambridge University Press.

Whaley, D. and Leinen, M. S. 2018. *Geoengineering could buy the time needed to develop a sustainable energy economy*. Chicago: Bulletin of the Atomic Scientists.

Wiertz, T. 2016. Visions of Climate Control: Solar Radiation Management in Climate Simulations. *Science, Technology, & Human Values* 41(3): 438–460.

Young, O. 1989. *International Co-operation: Building Regimes for Natural Resources and the Environment*. Ithaca: Cornell University Press.